AGENCY OF INSECTS IN FERTILIZING PLANTS.

BY W. J. BEAL.

MR. CHARLES DARWIN and other botanists have proved beyond a doubt, that some flowers, in which the pollen may easily gain access to the stigma of the same flower, are sterile unless fertilized by pollen borne from other flowers, while many are much more productive by a cross fertilization.

For information concerning the peculiar manner in which fertilization is effected in the Balsam, Wood-sorrel, Violets, Dicentra or Dielytra, Corydalis, Mitchella or Partridge-berry, Oldenlandia or Houstonia, Primrose, Barberry, Lysimachia or Loosestrife, Orchids, Dutchman's Pipe, and others; consult the observations recorded by Mr. J. T. Rothrock in the second number of the NATURALIST, Mr. Darwin's work on the "Fertilization of Orchids," and seven articles by Dr. A. Gray in the "American Agriculturist," beginning in May, 1866.

With the fact that insects are necessary to fertilize some plants, and the theory that all are improved by crossing, let us see how this is accomplished in plants which may not seem to require the aid of the wind or insects. Plants are very rarely found in which the pollen may not, occasionally at least, get to the stigma of another flower of the same, or an allied species. Then if the pollen is "prepotent" or most effective on stigmas when thus transferred, a cross is very sure to result, even though much pollen comes in contact with the stigma of the same flower. Dr. Gray, acquainted with these facts, and familiar with the structure of the Iris, saw that insects must be needed for the fertilization of this plant also, and without seeing the bees upon them, shrewdly pointed out the manner in which

they must carry the pollen from one flower to another. We verified his theory by observations made two years ago, and found it to be true in the essential particulars.

Without giving a scientific description of the flower, it is enough for our present purpose to say, that the parts consist of three curved tubes, each just about large enough to admit a common honey-bee, being a trifle larger than a cell in her comb.

There is a showy crest, or attractive platform, projecting at the outer end of each tube upon which the bee first alights. When going into the flower for the first time during the day, she is free from pollen. She brushes against a lid which hangs from above, not unlike an old-fashioned swinging door of a cat-hole, as sometimes seen about barns or corn-cribs. When farther in beyond the lid, she comes against the anther, which only discharges pollen on the side next to the bee's back. After getting what nectar she can at the lower end of the tube, she backs out again, pushing the trap-door in the opposite direction. The outside of this door is the only part of the stigma upon which the pollen will produce any effect, so upon visiting the first tube no pollen adheres to the sensitive side of the stigma, although the bee leaves the place with her back well powdered. Calling at another tube, she dives in as before, this time dusting the outside of the lid with pollen which was brought from the tube first visited.

In the early part of June, I examined the common Blue Flag (*Iris versicolor* Linn.) at different times during the day, and always succeeded in seeing the bees at work while their heads and backs contained an abundance of pollen. In wilted flowers, and in some that were fresh, I saw bees occasionally get in and out at the side of the

tube, without touching the stigma at all. Sometimes they went in the tube as first described, and then slipped out at the side instead of backing out. Several went on top of the flower and tried to find other ways to get at the sweets below, but in every instance they failed, and soon left that position.

At the Botanical Garden, Cambridge, Mass., I noticed bees on several foreign species of Iris, in some of which, as *Iris pseudocarus* of Southern Europe, the tube is more nearly perfect, so that it is impossible for them to find a side entrance or egress.

The corolla of *Andromeda floribunda* Pursh, is nearly urn-shaped, hanging with the open end or entrance down. The ten long anthers open at the apex by two round holes, and each anther is supplied with two horizontal or reflexed awns on the outside next the corolla. The stigma is just at the narrow mouth of the corolla. Bees in abundance visit the flowers, thrusting their long tongue or proboscis against the awns or horns of the anther, as they reach in for nectar which is secreted farther on. By hitting the awns the anthers are disturbed, and the holes brought close against some part of the bee's proboscis, which is well sprinkled over with pollen, as well as the other mouth parts hanging below the flower. Bees were examined, and found to have the parts mentioned covered with the four-grained pollen which is peculiar to a few plants.

I cannot see how pollen alights on the stigmas of this plant, for in falling out in the natural way it must pass by to the ground. But the insect puts the material in place every time as effectually as a mason can stick mortar on the ceiling of a room. The Blueberry (*Vaccinium*) is similar in structure to the *Andromeda*, except that the

awns are wanting. Probably most flowers which droop or hang down are fertilized by insects. For otherwise, how can the pollen find the tip of a stigma, when the style is suspended?

The mode of fertilization in the American Laurel (*Kalmia*) has already been well described in the NATURALIST, but I may be excused for adding my testimony concerning this beautiful and interesting plant.

When the anthers are liberated from the pockets in the corolla, the stamens suddenly straighten and throw jets of pollen often for a foot or more, "acting," as Professor Gray used to say, "like a boy's pea-shooter."

Many times when the dew was on, I have seen the common honey-bee and other *Hymenoptera* about these flowers. When the bee alights on a flower, the style comes up between the legs where they join the body, or sometimes farther back against the abdomen.

In this position they turn around, as though they were balanced on a pivot, generally inserting the tongue outside of the filament, and, while doing this, pull the stamens with their legs towards the centre of the flower, releasing them and frequently receiving the shots of pollen on their own body. A single visit from an insect is sufficient to release all the anthers. By noon it was a difficult matter to find a flower which had not been visited in this way. Insects seem to be absolutely necessary for the perfect fertilization of *Kalmia angustifolia* and *K. latifolia*, for I tied small nets over some flower-clusters (*corymbs*), and found that when the bees were kept away, the flowers withered and fell off, most of the anthers still remaining in the pockets, and the filaments so decayed that their elasticity was entirely gone. The very few an-

thers liberated were probably brought out by the shaking of the bushes by the wind.

Considerable pollen was found stuck on the corollas by the nectar, which was uncommonly abundant, as no insects of much size were allowed to remove it. The wind might have carried some of this pollen to other flowers, or it might have dripped from those above to flowers below in drops of water (there were two showers during these experiments); but I infer this was not the case in the examples mentioned, because the flowers, especially the stigmas, remained fresh much longer than those which were left exposed to the visits of insects.

The flowers of several Honeysuckles, of the Mustard Family (*Cruciferæ*), of the Bladder-nut (*Staphylea trifolia* L.) were noticed, and in each case the conclusion reached was, that the chances are better for cross fertilization than otherwise.

The long cylindrical, bell-shaped corollas of the Purple Foxglove (*Digitalis purpurea*) are much visited by bees. The flowers are mostly obliquely suspended, and in all thus situated, the stamens and style are close to the upper side of the corolla. The insects alight at the opening of the corolla, on the side opposite the stamens. This is generally the lower side as the flowers hang, then reaching above, they catch hold of the style and stamens, and crawl in with the back down, brushing the whole length of the underside of the body, first against the stigma, and, farther on, against the anthers.

They seem unable to get into the flower without catching hold of the stamens, and it is often with considerable difficulty that they enter at all, for they are obliged to hold on to the edge with the hind legs until they can catch the stamens with their fore legs.

In the Evening Primrose (*Oenothera glauca* Michx., *Oe. Missouriensis* and *linearis* Michx.), the stigmas project beyond the anthers, and the flowers vary from an erect to a horizontal position. There are four large stigmas for each style, spreading in the form of a Greek cross.

The pollen, slightly held together by delicate threads, is collected in the morning by great numbers of small wasps, about two-thirds the size of honey-bees. I have often watched them while coming down on, or just over, the stigmas, leaving pollen as they went in, and after collecting what they could, fly out at the side without touching the stigma. On one of these plants, at two different times, a wasp was eagerly trying to pick up the pollen which had been left on the stigmas; the more they tried to collect, the more they scattered pollen about on the glutinous surface, until, as if discouraged or disgusted, they rapidly cleaned their legs of all the tangled mass, and flew away, leaving that cluster of flowers entirely.

In the flowers of the Pea, False Indigo, Yellow-wood (*Cladastris*), Red-bud or Judas-tree, Red and White Clover, Locust, and others of this large and important family (*Leguminosæ*), the anthers surround the stigma, and are closely covered by the corolla. This certainly looks like a very clear case for self-fertilization, but I doubt not the reverse is very often the case. Many of the flowers, as the Pea and Locust, have one petal much larger than the rest, called the standard or banner. Opposite this is another part composed of two petals sometimes united, termed the keel. On this keel bees uniformly alight, and crowd the head down next to the banner-petal. To enable them to do this, they kick the keel and side petals (wings) with their hind legs, and push them back so that the anthers and stigmas

come out from their concealment and meet the underside of the insect where pollen may be left or received. Why the style should be so uniformly curved upward, and all should be brought against the abdomen of insects, I cannot well conceive, unless it be of some use to the plant.

Lupine, another species in this family, has a remarkably long keel which makes a close sheath for the inside parts. On the style, just below the extremity, is a circle of long stiff bristles. As the keel is pushed down, only the stigma, with the bristles below, appears outside, and this pushes out a mass of pollen which generally hits some part of the insect. When left, the flower resumes its former position again.

For about six times pollen can be pushed out in this way, when the supply becomes exhausted. Insects begin on the lowest flowers, and so go up the spike to others which are higher and younger. No experiments have been made on Lupine to show whether it will produce more seeds when visited by insects than when protected.

ICE-MARKS AND ANCIENT GLACIERS IN THE WHITE MOUNTAINS.

BY A. S. PACKARD, JR., M. D.

During a visit last autumn to the White Mountains, we found ice-marks in the valleys of the Saco, Ellis, and Androscoggin Rivers. These grooves, and other signs of ice action, give the clearest evidence, that, during the Glacial Period, the White Mountains were covered by a central *mer-de-glace*, which discharged local glaciers into the principal valleys radiating from the central peaks.

Like the glaciers of the Alps, of the mountains of